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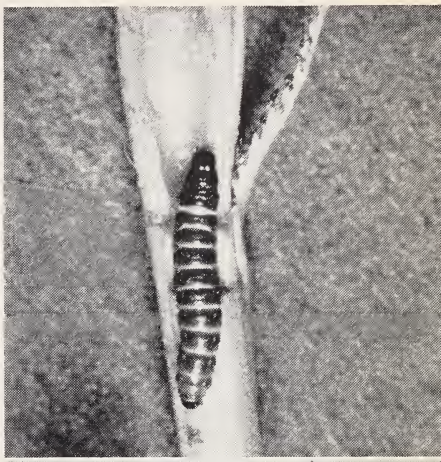

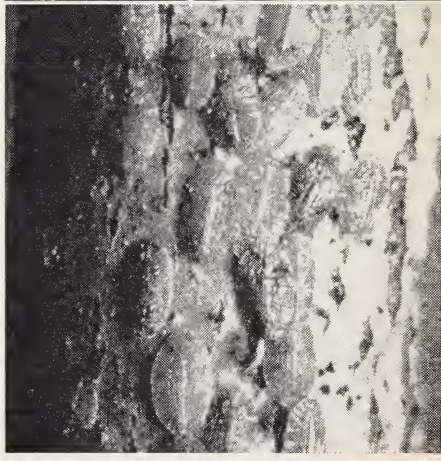

INSECT and MITE

PESTS of ALMONDS

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INSECT and MITE

Almond growers must be able to detect signs of a pest infestation early to prevent its spread. This publication tells how to recognize major insect and mite pests and describes their life histories. Almond pesticides, as well as the problem of preventing hull contamination, are discussed but no specific spraying programs are given.

For information about

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At least thirty distinct species of injurious insects and mites attack California's almond orchards. Some are widely distributed, while others invade very limited areas. The pests are not specifically restricted to almond, but may infest other fruit trees, especially peach. The almond is, however, a preferred host for several pests, particularly the peach twig borer and the brown mite. Pesticides which are safe for use on stone fruit trees must be used much more cautiously on almond trees to prevent contamination of forage hulls.

Almond insect and mite pests can be grouped into five categories: moths, mites, plant bugs, scales, and wood-boring beetles. Of these, the moths are perhaps the greatest economic menace to almond growers.

PESTS of ALMONDS

Moths

Important moth pests . . . type and extent of damage . . . habits . . . use of pesticides

PEACH TWIG BORER

The peach twig borer, *Anarsia lineatella* Zell., is one of the most damaging pests of almonds. From 1933 to 1952 the total yearly damage to Nonpareil meats delivered to the California Almond Growers Exchange ranged from 1.00 to 8.34 per cent by weight. The larvae feed mainly on the hull or outer shell tissues and rarely attack the meats of hardshell varieties. However, when heavy infestations develop, some of the larvae enter the nuts and damage the meats of softshell varieties. The surfaces of ripening meats are usually scored or etched away with shallow channels or, occasionally, small bits are chewed away from the pointed ends. Actively feeding larvae (worms) are rarely found in dry nuts on trees or in stored nuts or meats.

The larva of the peach twig borer can be recognized by its body color and twig-mining habit. A mature larva is about ½ inch long. It has a black head and a red-brown or chocolate-colored body. The soft membranes which join the body segments together are pale brown, so that wide bands of darker color alternate with narrow bands of lighter color. The adult stage of the twig borer is a small slate-colored moth. During daylight hours it rests on shaded trunks and main limbs of host trees. The moths are so well camouflaged that they are very difficult to find unless the rough bark and bark crevices are intently searched.

Habits. The larvae of the twig borer feed primarily within the tender twigs of stone fruit and almond trees. A larva just out of the egg stage usually bores into the petiole of an immature leaf near a terminal bud, and then moves downward 2 or 3 inches through the core of the shoot. Since mined twigs die back, the number of twig borers is roughly indicated by the number of dead terminals showing after a brood of larvae has matured.

Very young larvae winter under the

Infested twig split open to show burrow and mature larva of the peach twig borer.

soft bark of young wood. Many of those which hatch from eggs laid during the latter part of the growing season chew directly into the tender bark or callous tissue in the crotches of small branches where they construct cavities called hibernacula. They become quiescent when established, and overwinter as very small, immature worms. Apparently, the whole orchard population of twig borers is confined on the exposed wood of fruit and nut trees between growing seasons. **Winter sprays which kill the hidden larvae are therefore of strategic value.** Dormant sprays containing spray oil plus certain organophosphate insecticides are effective against the hibernating larvae.

The small larvae emerge from their hibernacula during the blooming period, the first few coming out during late January. Emergence builds to a peak during the first half of March and then declines, but diminishing numbers of stragglers may appear until mid-April. Thus the new season of twig borer attack begins with a brood of larvae generated the season before.

Since foliage is undeveloped at the time

Below. Terminal shoot killed by a peach twig borer.

of peak emergence, larvae bore into unopened fruit and shoot buds; later, they establish themselves in larger shoots to finish the feeding stage. **Excellent control can be accomplished by spraying to destroy emerging larvae of this brood during pink bud or immediately after petal fall.** Chemicals which control twig borers should not be used during the blooming period because they are harmful to pollinators.

All larvae of the overwintered brood mature and move out of the foliage during April. This phase ends about May 1; during April and May the larvae spin cocoons on the tree trunks and transform into moths. Eggs laid by these moths begin to hatch between May 10 and May 20, and this new brood mines twigs during late May and all of June. Sprays applied at the onset of this attack are known to give excellent results but pesticides used at this period can cause illegal contamination of forage hulls. Present and future pesticides acceptable for use during this first multiplication period must be applied with full understanding of the prevailing residue restrictions.

A third brood begins to appear during early July. Larvae of this and possibly a fourth brood appear almost continuously throughout the crop-ripening period and some of them feed on maturing nuts. **Controlling these later broods is very difficult and cannot be assured.**

Chimney of silk and frass in twig crotch marks location of a live peach twig borer larva in its hibernaculum.

NAVEL ORANGEWORM

The navel orangeworm, *Paramyelois transitella* (Walk.), is a moth pest which first appeared in Mexico and Arizona as a scavenger of citrus fruits. Within the past fifteen years it has become widespread throughout the almond and walnut growing areas of California. It can survive and propagate in nut and fruit orchards when suitable food is available. Apparently within several seasons after infestation, the pest builds up to a noticeable economic level. It then regresses to a low-grade chronic infestation which causes only minor loss but still presents the threat of serious outbreak.

The navel orangeworm moth is small (wingspread is approximately $\frac{5}{8}$ inch) and pale gray with brown and black markings. The mature larva, or worm stage, is about $\frac{3}{4}$ inch long and is cream, flesh or pale pink except for its dark-brown head. A tiny inverted crescent or horseshoe of dark skeleton is located high on each side of the second body segment behind the head; this partly surrounds two bristles and is hardly visible except with a pocket magnifier. Larvae are apt to be present when recently harvested

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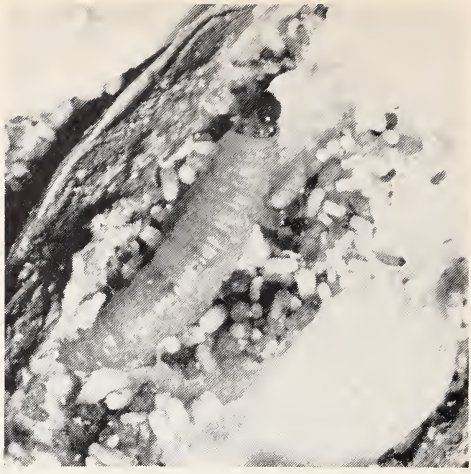


Above. Larva of navel orangeworm in a Nonpareil almond.

Left. A navel orangeworm moth.

almonds are opened. Older larvae may be identified by their method of feeding on almond meats. They devour substantial amounts of kernel, forming cavities or tunnels which are partly filled with frass (excrement pellets) and dirty web.

Habits. The habits of the adult or moth stage are not well known, but presumably adults do not survive the winter. Eggs laid when the growing season is about to end produce larvae which overwinter within mummy fruits or unharvested nuts. The nuts may be stick-tights or good nuts left hanging or lodged in crotches of the trees. Larvae in young or advanced stages of growth, and even pupae or chrysalids, often occur together within one fruit or nut. The navel orangeworm does not appear to have a true quiescent or hibernating stage. Low temperatures merely slow growth and feeding processes.

Since the larvae do not feed on whole, green almonds, the population is perpetuated on holdover nuts during much of each year. Moths active in spring months lay eggs on year-old nuts, some of which already contain larvae of an earlier generation. Reproduction continues throughout the growing season; there are no clear-cut worm broods or intermittent moth flights.

Since orangeworms do not bore through almond hulls, the larvae infest nuts of the new crop when the hulls begin to crack in the preharvest period. A few larvae mature and produce moths before harvest but most remain in the nuts until

Pupa of navel orangeworm in a mummy almond during spring. Kernel is entirely consumed.

the crop is harvested and are carried over into the storage period. Maturation time in stored nuts varies according to the age of the larvae on harvest date and according to temperature. Low temperatures greatly prolong the time required to complete growth.

This pest is also a processor's problem because live worms continue to damage nuts in receiving depots and storage bins. Orangeworms are "dirty feeders"; as meats are partly devoured, coarse frass and profuse webbing appear on them. A full-grown larva generally leaves the infested nut in search of a place to spin its cocoon, and as it moves about it produces copious amounts of dirty web which binds nuts together and contaminates sacks or bins. Processors can lessen this problem by fumigating all infested lots immediately on arrival. This sanitation procedure benefits the producer, because larvae which are very small at the time of fumigation are destroyed before they can do enough damage to make meats unsalable.

No practical spray procedure has been devised to control the navel orangeworm. Test sprays of the best insecticides now known (applied in one or two sprays after hull-crack) have not significantly reduced crop damage. On the other hand, **research has shown that sound crop management can reduce crop losses.** These four procedures have proved profitable: 1) Harvest trees as completely as economics permits, removing unharvested crops from diseased or neglected trees. 2) Harvest susceptible varieties (IXL, NePlus, Nonpareil, Drake) as early as harvesting methods and good quality permit. 3) Route susceptible varieties through the huller first; unhatched eggs on fresh hulls are a threat to meats until hulls and nuts are separated. 4) Ship lots to the processor immediately for fumigation, if the service is available.

Almonds picked in mid-April to show damage caused by larvae of fruit-tree leaf roller.

Mature larva of a tent caterpillar.

OTHER MOTH PESTS

Although twig borers and navel orangeworms are the major moth pests which attack near-ripe almonds, others which cause only minor losses complicate worm identification.

The fruit-tree leaf roller, *Archips argyrospilus* (Walk.), attacks almonds in the late jacket period. The moth has a wide host range but is perhaps best known as a spring pest of apricots. The eggs, laid on small branches in button-like masses, begin to hatch during March or April. The larvae chew on leaves and tie them in rolls with tough strands of web; they also enter young almond fruits and devour the kernel. Crop damage, which is completed by the end of May, can readily be identified: dry, collapsed nuts of about one-third final size have fairly large slotlike holes into the kernel chamber but no kernels; often traces of web and a rim of frass surround the hole. Leaf roller infestations are local, sporadic, and usually minor. A petal fall spray gives effective control.

California tent caterpillars, *Malacosoma californicum* (Pack.), are large, gray or brown hairy larvae with a line of blue along each side. They are leaf feeders, appearing in spring in a few localities. Tiny larvae hatch from masses of eggs affixed to the tree bark and soon spin sheets of web enmeshing one or more small shoots per tree. Later the large, mature caterpillars disperse to wander about on limbs and foliage before transforming into moths. Satisfactory control can be obtained with residual insecticides applied during the petal fall period or shortly afterwards.

The western peach tree borer, *Sanninoidea exitiosa graefi* (Hy. Edw.), sometimes infests almond trees in counties near the San Francisco Bay area. This moth is a wood borer; its larvae are considerably larger than those of the prevalent fruitworms. They attack tree trunks close to the ground line (frass and plentiful gumming are revealing symptoms) seriously damaging the tree if the larvae are numerous or if the attack con-

tinues for several seasons. The moths and eggs appear from late April through September, with a peak emergence close to August 1. Persistent pesticides, applied as trunk sprays at bimonthly intervals from May 15 through August, have been successful. Trunk sprays must be confined to the required part of the trees and not allowed to splatter onto fruit or foliage.

The American plum borer, *Euzophera semifuneralis* (Walk.), is one of several species of moth larvae sometimes found in the gummy, callous tissues of crown galls. This insect sometimes becomes troublesome on new grafts. Scar tissue or callus formed at the union of scion and stock attracts this borer, and it works to undercut or girdle the graft. Brownish frass, web, and gum pockets indicate its presence. Excess grafting wax and detritus should be brushed away and the affected parts sprayed with DDT. Unharmed grafts should also be treated. Although standard procedures to control the pest have not been evolved, it is believed that several applications of DDT are required to extend protection until scion-stock unions heal and harden.

Work of western peach tree borer beneath heavy bark near ground line.

The codling moth, *Carpocapsa pomonella* (Linn.), a major pest of apples, pears, and walnuts, occasionally attacks almonds, but infestations so far identified have been isolated and trivial. The raisin moth, *Ephestia figulilella* Greg., infests almond kernels during the harvest period but is not a significant orchard problem. This species and its close relative, the almond moth, can be troublesome storage pests, however. Another fruitworm is the filbertworm, *Melissopus latiferreanus* (Wlsm.), which breeds on oak galls and occasionally causes trouble in a few localities as an almond pest. No sprays are recommended, but the crop management procedures recommended for navel orangeworm can minimize damage.

An important and common storage pest is the Indian-meal moth, *Plodia interpunctella* (Hbn.). Although it infests almonds on trees, it is of no great consequence unless neglected when nuts are stored for long periods.

New information and regulations about almond pesticides are constantly being developed. Growers interested in obtaining information on specific pesticides and conditions of use should secure the current University of California pest control recommendations from their Farm Advisors or from the Public Service Office.

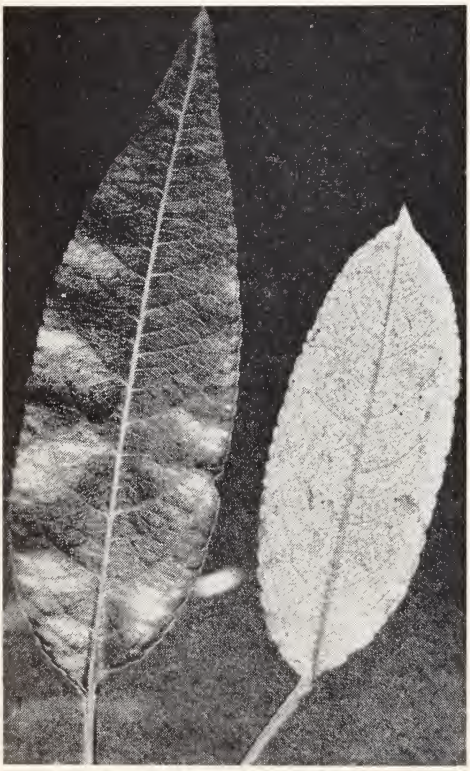
Mites

Important mite pests . . .
how to recognize them . . .
habits and methods of attack

Many species of mites occur in almond orchards. Some are harmless inhabitants of topsoil, moss, lichens and moist tree bark; others are known to be predaceous and probably beneficial. Only harmful species will be discussed here.

BROWN MITE

The brown mite, *Bryobia arborea* (M. and A.), is the first spider mite to appear in spring. It resides on the woody parts of the tree, feeding on the upper sides of almond leaves when conditions are favorable. This mite winters in the egg stage. Eggs are cemented to the surfaces and in the crevices of wrinkled bark, sometimes in such large numbers that patches of wood have a reddish tinge. The eggs are spherical, cherry red, and have no filamentous attachments; freshly hatched mites are very small, fiery red, and have but six legs.



Almond leaf badly damaged by brown mite on the right. Leaf at left is bright green and free of mite damage.

The mites wander on foliage, distributing their feeding punctures widely over leaf surfaces. Day-to-day changes in leaf symptoms are therefore difficult to detect. Affected leaves first become mottled, then decidedly yellow. Badly damaged foliage is bleached and covered with minute flecks of dried sap. Defoliation, however, is not a characteristic symptom of brown mite damage.

Habits. Hatching of brown mites begins in late February and proceeds rapidly throughout the blooming season. The so-called larval stage is succeeded by two nymphal growth stages before adults are formed—usually not before April 1. A multiplication period follows during April, when eggs are laid in large numbers before the adults die. A second generation of mites develops in May, and a third generation in June. Infestations recede during hot July weather, because most of the eggs laid during this period do not hatch. These eggs remain inert throughout the summer and the ensuing winter.

Egg masses can be destroyed by dormant sprays containing oil and a suitable organophosphate insecticide or by specific mite ovicides applied just prior to bloom. **Control of actively feeding mites at petal fall or later is best accomplished with persistent spray materials, lethal to both the active mites and their developing eggs.**

EUROPEAN RED MITE

The European red mite, *Panonychus ulmi* (K.), is a common spider mite pest of apple, pear, plum and, in some areas, peach. Although a serious fruit tree pest, it is not yet prevalent on almond. However, it appears to be adapting to almond, since economic infestations are being reported with increasing frequency. Because European red mite has quickly acquired resistance to a wide range of today's chemicals, it is difficult to control.

The pest winters in the egg stage as does the brown mite. The eggs are amber red and slightly flattened, often with a small filament projecting from the center of their exposed surfaces. The active, mature females are wine-red, with prominent back bristles projecting from white tubercles.

These mites do not congregate in well-defined colonies on leaves. They are apt to be more difficult to control than brown mites because they continue to work well into late summer and may breed long after spring sprays have lost effectiveness. Symptoms of their feeding closely resemble brown mite damage, and almond growers who experience chronic troubles with "brown mites" should make certain that the offender is actually not the European red mite.

PACIFIC SPIDER MITE

The Pacific spider mite, *Tetranychus pacificus* McG., sometimes locally called "red spider," attacks the almond in summer. It is green to yellow amber in the active stages, while the eggs are colorless spheres. A closely related species is the two-spotted spider mite, *Tetranychus telarius* (Linn.). Although properly distinct species, the Pacific and two-spotted spider mites are so much alike in time and mode of attack, symptoms produced, and responses to chemical sprays, that the distinctions are not of consequence in practical control. Both frequently intermingle on one tree and, occasionally, on a single leaf.

The Pacific spider mite is web-spinning, forming colonies on both upper and lower leaf surfaces. The leaf damage is localized; compact colonies produce a slight cupping effect in the leaf and a local area of chlorosis (yellowing) or scorch. The species rarely attacks before the advent of summer, but significant numbers appear quickly after warm weather begins in June or July. Trees already partly damaged by brown mites are likely to shed leaves sooner than those not damaged beforehand. Attack by Pacific spider mite characteristically begins in the driest and dustiest portions of orchards, then becomes general unless cool weather intervenes. Nonirrigated orchards are most susceptible; sprinkler irrigated orchards appear to be least vulnerable. If this species attacks severely before nuts complete development, counter measures are imperative to prevent sticktights and pinched kernels.

Control of Pacific and two-spotted spider mites with modern miticides is quick and effective. One application of a residual miticide normally holds the infestation in sufficient check; biological control usually takes over when chemical control lapses and the mites are unable to rebuild damaging populations before the onset of cool weather. Premature application of spray or incomplete coverage, as well as protracted periods of high temperatures, increase the likelihood of a recurrent attack, however.

The silver mite of peach, *Aculus cornutus* (Banks), also attacks almond trees. These mites, which are a species of leaf gall mites, are extremely small, flesh-colored leaf feeders, which stipple otherwise healthy green leaves with pin-point chlorotic spots. The symptoms resemble thrip or leafhopper damage. At present this species is not economically important in almond culture.

Plant Bugs

Identification of the most damaging species . . . type of damage . . . two less important species

BOXELDER BUG

The boxelder bug, *Leptocoris trivittatus* (Say), affects bottomland orchards, especially in districts where boxelder, oak and elderberry abound. Adults are approximately ½ inch long, slender, and gray-brown to black. The orange-red color of the body beneath the wings is noticeable when the bugs are in flight. Boxelder bugs overwinter as adults which invade almond orchards very soon after blossoms fade. This migrant population is primarily responsible for crop damage. The pests can breed in orchards, depositing eggs which are an aid to identification. These are laid singly or in groups of two or three; they are small, bright red, bean shaped, and are deposited on the surface of leaves and nuts. One or more eggs are frequently laid in the slight depression near the pointed ends of nuts. Immature bugs (nymphs) are also bright orange-red until about half grown. Infestations persist in almond orchards until about June 1.

Adult boxelder bugs on nuts during May.

Samples of Nonpareil meats attacked by boxelder bugs. The nuts on the left are marked by isolated dark kernel spots; meats on the right are more severely damaged.

Damage caused by boxelder bugs is two-fold. Small nuts just pushing out of dry jackets wither and drop, while larger nuts which can sustain several bites without withering, suffer internal gumming. Stings which pierce the nut to the kernel set up a local reaction. The tender kernel first develops a circular, translucent spot which later dries and forms a dark depression. The shell tissue produces a wartlike growth inside the kernel chamber. These symptoms are evident only when the nuts are opened for inspection. Most affected nuts show no outward signs of damage but during April some begin to drip gum in long, twisted threads. Crop damage is extensive by this time.

The critical period of attack by boxelder bugs extends from about ten days after petal fall until the end of April. Sequences of TEPP sprays in semicon-

Leaf-footed plant bug on nut.

An adult consperse stink bug.

centrate form or full-volume sprays of parathion give some control.

Comparable symptoms of dark kernel spot and fruit gumming are caused by two other related insects: the leaf-footed plant bug, *Leptoglossus clypealis* Heidm., which on rare occasions invades almond orchards during middle spring, and the more prevalent consperse stink bug, *Euchistus conspersus* Uhler, which migrates into orchards during late May or early June. Adequate spray remedies have not been devised to combat either species. Almond crop losses from nominal infestations of these plant bugs are not critical, however, because most of the damaged kernels are accepted in grade.

Scales

Important scale insects . . . type of damage . . . identification . . . pesticides

As a rule, almonds are reasonably free from the scale insect attacks which devastate stone and pome fruits. But local outbreaks on almonds, sometimes of extreme importance, do occur. Scale insects attack young scaffolds and brushwood, reducing vitality, killing local tissues involved in tree growth, reducing the crop, and shortening the life-span of infested trees (spotting of almond fruits by the insects is unimportant). Badly affected limbs drip gum, split as with sunburn, and usually are later killed by wood-boring beetles. Three common species of scales attack almond: San Jose scale, *Aspidiotus perniciosus* (Comst.), olive or parlatoria scale, *Parlatoria oleae* (Colvée), and European fruit lecanium, *Lecanium corni* Bouché.

San Jose and olive scales are much alike in appearance and habit. Both are armored scales; their tiny yellow (San Jose) or purple (olive) bodies secrete tough, waxy shells (scales) which both protect and camouflage the insects. The slate or gray scales are slightly convex and so closely resemble wood pores that they appear to be normal parts of

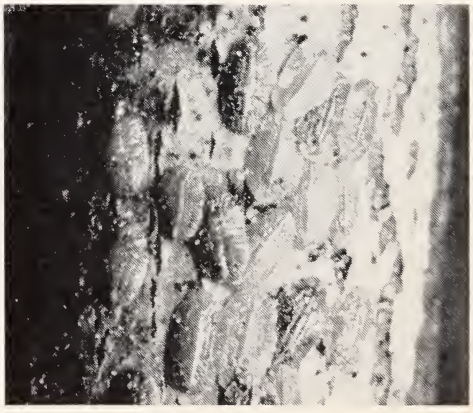
Smooth bark well infested with immature stages of San Jose scale.

the bark to which they are permanently attached. Neither adult females nor intermediate growth stages of these insects move from place to place. During spring months, olive scales lay eggs which accumulate in brood chambers beneath their shells. Hatching begins during the latter part of April. San Jose scales begin to reproduce about mid-May. Eggs hatch almost at the instant of laying, or even slightly before, and the young crawlers push out from under the shells of mother scales to become free-living for a brief time. Whether born alive or hatched from eggs, the crawlers scatter to infest new wood or fruit and leaves. When the crawlers settle they develop a permanent attachment to the host, lose their capacity to move from place to place, and gradually form a covering shell. There are two to four generations of crawlers per year.

European fruit lecanium, a copious producer of syrupy honeydew, is called an unarmored scale because its outer covering is merely a much-thickened, leathery integument of its body wall. Mature females, which develop in spring, are quite large, about 3/16 inch across, convex or domed, and brown or mahogany-colored. They are extremely difficult to kill with spray chemicals appropriate for spring use. Their vital organs waste away as eggs accumulate under the arched canopy of body wall. The eggs hatch from May to July, producing only one generation a year. European fruit lecaniums winter as semimature nymphs which can be controlled with dormant sprays. During early spring, soon after bloom, these almost naked immature forms quickly harden, hump up, and become rubbery. They are then resistant to pesticides until the brood of young appears.

Use of pesticides. Excellent control of European fruit lecanium and San Jose scale can be obtained with dormant oil sprays at concentrations of 3 gallons miscible oil or 4 gallons oil emulsion per 100 gallons of water. Oil sprays require sufficient rainfall beforehand and should not be applied after floral buds show pink. For olive scale, an added organophosphate is desirable. An optimum dosage includes three gallons oil emulsion (or equivalent emulsive oil) plus two pounds 25 per cent parathion wettable powder, or an optional organophosphate insecticide.

Spring or summer sprays for scale insects are rarely used on almonds. Those which are known to be effective when used on peaches and prunes can be adapted to almonds when registrations for such use are obtained.



Immature stages of European fruit lecanium on small twig, at the end of winter.

Beetles

Wood-boring beetles . . .
identification . . . control
suggestions

Sound, vigorous orchard trees are rarely molested by boring beetles. Shothole borers usually attack trees already weakened by root diseases, insufficient irrigation, scale insects, chronic mite infestations or other causes of growth retardation. Flat-headed borers are attracted to diseased or injured limbs. Especially susceptible limbs are those affected by sunburn, scale insects, bacterial canker, mallet wounds, and breaks or major pruning cuts.

Very small black beetles called **shothole borers,** *Scolytus rugulosus* Ratz., burrow into bark to feed and lay eggs. A number of grubs or larvae are produced within this burrow and they, in turn, undermine the bark with secondary galleries. The galleries extend radially from the central holes. The entrance or exit holes are cleanly bored, circular, and just under $\frac{1}{16}$ inch in diameter. These telltale holes can be numerous on unthrifty limbs. When infestations build up, some of the adults bore into buds or into small twigs at the bases of buds. There are two to three broods each year.

Another common boring beetle is the **Pacific flatheaded borer,** *Chrysobothris mali* Horn. The full-grown larva of this species is about $1\frac{1}{4}$ inches long, white to flesh-colored, and has a prominent, flat enlargement of the body just behind the head parts. The larvae excavate large, irregularly shaped caverns beneath injured bark and bore large tunnels deep into the sapwood. The excavations are usually filled with finely powdered sawdustlike matter, so often seen in the cut ends of cordwood.

Branch (apricot) showing shot-hole borer damage. (Photo courtesy Dr. Harold F. Madsen.)

Prevention is the best control. Sequences of sprays to control wood borers are not practical, but it is possible to abate attacks by pruning out all badly infested wood during winter, sealing the cuts, and restoring growth vigor as far as possible. It is advisable to burn infested prunings before the growing season starts. Cordwood cut from infested trees should be hauled far away from fruit orchards before spring.

Pesticides

Poisonous spray residues . . .
danger to human beings . . .
contamination of forage hulls

Prior to 1949, the outer fleshy covering of the almond fruit—the hull—was a waste product. But during the period 1949 to 1951, it was discovered that almond hulls are of value as food for livestock, particularly lambs and cattle.

Acceptance of hulls as animal forage introduced complications in pest control, however, and in 1955 the Federal Food, Drug, and Cosmetic Act of 1938 was extended and made more specific by legislation known as the Miller Amendment. Since that date permissible contamination from residues of poisonous substances has been set very low for forage crops (forage hulls in the case of almonds) to avoid contaminating meat, butter and milk. This greatly restricts the use of pesticides on almonds.

Oncoming crops of almonds sometimes require spraying when the fruits are green and heavy. A drying period follows, after which hulls and nuts are separated. Drying and hulling remove much of the weight but leave all or nearly all of the spray residues on the hull portion. Thus the contamination originally present on the whole green fruit concentrates in the dried hulls in direct proportion to the amount of drying. Passage through animals introduces a second concentrating process, and residues originally spread over a large volume of forage hulls may accumulate in the animal tissues and, finally, be concentrated in a small volume of fat or milk.

Qualified investigators can determine which pesticides present particular hazards for stock animals and, ultimately, the human consumers. The "proving out" of new and even old spray chemicals is proceeding slowly, and at present very few materials are registered for use on almonds after the nuts are formed. The list of registered chemicals should grow in time; in the meanwhile the almond producer must bear in mind two salient points:

1. Indiscriminate use of pesticides classed as poisons can jeopardize public health. It is necessary for growers to produce almonds which conform with standards defined by the pure food laws.

2. Almond kernels or meats are much less likely to be contaminated by sprays than are the hulls. Thus certain chemicals may be registered for use on "almonds" but not on "forage hulls." When such materials are applied to green almond fruits the hulls should not be sold for animal forage. A grower is responsible for residues on his own crops.

BENEFICIAL ORGANISMS

Much work remains to be done on the biological control of almond pests by means of beneficial organisms. A bewildering assortment of creatures—such as insects, mites, fungi, and nematodes—comprise a part of each pest's environment. Each one affects one or more of the others, in complex ways, by competition or as parasites or predators. Weather changes and applied agricultural chemicals—even fertilizers—induce changes within this living system, whose variations are generally not entirely understood by man and, to a great extent, cannot be regulated. Nevertheless, the numbers of each species, pest or otherwise, rise and fall from time to time, and there are crop years in which certain pests are prevalent, other years when they are not.

Entomologists are continually alert for possibilities in biological control, and specialists in this field are sometimes able to find, multiply, and liberate introduced parasites or predators to benefit agriculturists. Unfortunately, this approach to pest control has not provided solutions to many of the urgent pest problems.

Without doubt, the future of pest control will lie not only in developing more useful insecticides but also in acquiring knowledge which will integrate cultural practices, chemical action, and insect population supplements. With this knowledge it may be possible to create and maintain a total environmental condition unfavorable for the pests.

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